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Soliton Pulse analysis in $AgAs_2Se_3$ Photonic Crystal Waveguide

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Abstract: Solitons are nonlinear waves that remain invariant as they propagate. Precise control of dispersion and nonlinear effects govern soliton propagation. In recent years Photonic crystals (PhCs) have attracted a great deal of attention due to the facility to engineer and enhance both their nonlinear and dispersive effects. In this article we show soliton pulse analysis in $AgAs_2Se_3$ PhC Waveguide using AUTO bifurcation analysis tool. We have demonstrated pulse compression at moderately slow velocities in $AgAs_2Se_3$ PhC waveguide. This is enabled by the enhanced self phase modulation and strong negative group velocity dispersion in the PhC waveguides.

Keywords: Soliton, Nonlinear Schrodinger Equation, Photonic Crystal, Photonic Crystal Waveguide, Bifurcation.
PACS: 47.20.Ib;02.30.Oz;42.65.Tg;37.10Jk;47.20Ky

I. INTRODUCTION

In recent years, Optical network traffic and its electrical power consumption have increased very rapidly. To deal with future growth, more advanced transmission systems, particularly photonic routers are anticipated. Photonic crystal slabs have become a promising class of dielectric structure for micro and nano photonics. Their ability to control light has already led the impressive demonstrations of various passive devices [1]. It is hoped that photonic crystal membrane will find utility in all optical processors for ultra fast and low power switching,optical logic gates, pulse regeneration, wavelength conversion, dispersion management and a variety other applications [2,3]. An experimental characterization and numerically modeled strong optical resonances in a chalcogenide glass photonic crystal membrane is discussed in [4].

When pulses propagate inside a nonlinear medium a variety of interesting effects take place with potentially practical applications. The support of soliton pulses is one of the remarkable properties in Kerr nonlinear waveguide. A soliton pulse can propagate undistorted in the loss less case, since self phase modulation (SPM) completely mitigates the effect of group velocity dispersion (GVD) induced broadening for this pulse. In this paper we analyze and demonstrate the soliton existence in GaInP photonic crystal waveguide using AUTO bifurcation analysis tool.

II. PROPAGATION CHARACTERISTICS

Pulse propagation inside a PhC waveguide is generally governed by nonlinear propagation equation [5,6]

$$\frac{\partial A}{\partial x}+\frac{\Gamma}{2}A+i\frac{\beta_2}{2}\frac{\partial^2 A}{\partial T^2}-\frac{\beta_3}{6}\frac{\partial^3 A}{\partial T^3}=i\gamma|A|^2A$$

Where A= A(x,t) is slow varying envelope function of the signal, Γ is the propagation loss coefficient , beta 2 and beta 3 are group velocity dispersion and third order dispersion coefficients respectively, gamma is SPM coefficient.

III. OUR MODEL

Present research was performed using a $AgAs_2Se_3$ Photonic crystal membrane with hexagonal lattice constant of 485 nm, a hole radius of 0.20a and a thickness of 170 nm with an added line defect of dielectric (fig 1). The dispersion was tuned by increasing the innermost hole radii to 0.22a. The propagation of optical pulses is modeled using nonlinear Schrodinger equation. The equation is solved and analyzed with the help of AUTO bifurcation analysis tool. We calculated the SPM coefficient and GVD coefficient using the data in [7] for loss less case and we take third order dispersion coefficient to zero.

IV. DISCUSSION OF SOLUTIONS

As can be seen from fig. 2, fig. 3, fig. 4 which are generated using AUTO bifurcation analysis tool we have demonstrated pulse compression at moderately slow group velocities in $AgAs_2Se_3$ Photonic Crystal Waveguides. This is enabled by the enhanced SPM and strong negative group velocity dispersion in the Photonic Crystal Waveguides. Use of material free of two photon absorption dramatically reduces the impact of nonlinear absorption and free carrier dispersion, thus preventing detrimental interference with the soliton dynamics. Nonlinear Schrodinger equation model gives qualitative agreement with experiments[7]. Owing to the small size of the device and low energies these results are promising developments in the integration of femtosecond and soliton applications in Photonic chips.

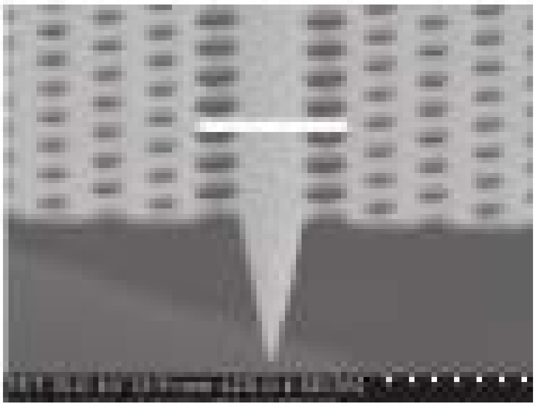

Figure 1. Photonic Crystal Waveguide

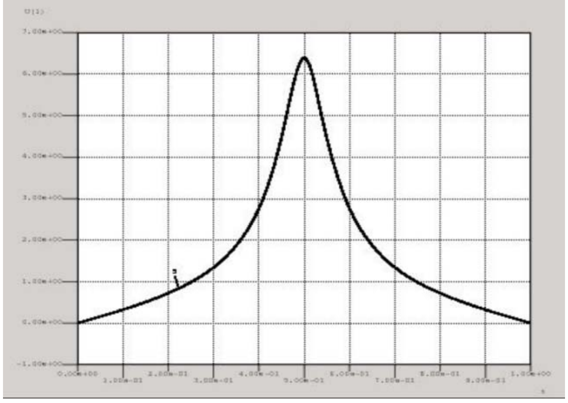

Figure 2. Function characteristics

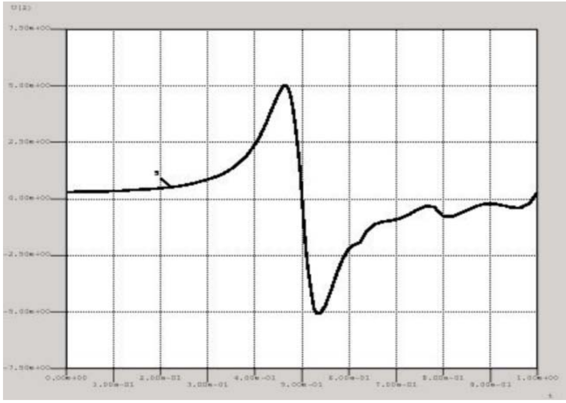

Figure 3. Function derivative characteristics

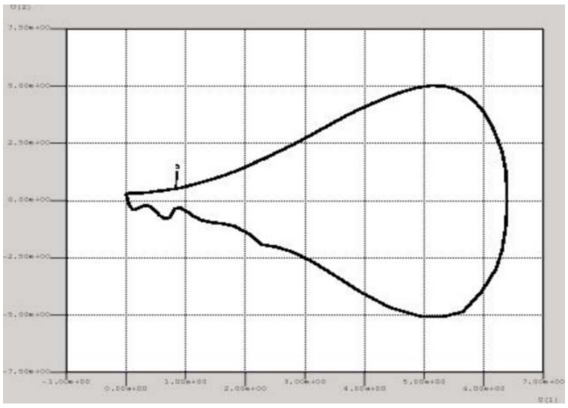

Figure 4. Relation between function and its derivative

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